

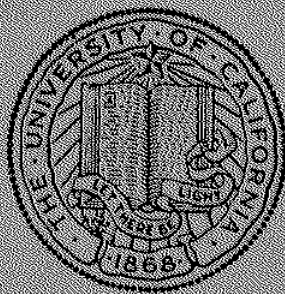
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Sea Grant Depository

The Scripps Institution of Oceanography

MARINE TECHNICIANS HANDBOOK

UNDERWATER CAMERA WIRE-LOWERED



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Sea Grant Publication No. 18

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GENERAL INTRODUCTION

This publication is one of a series intended to provide explicit instructions for the collection of oceanographic data and samples at sea. Individual chapters are being issued separately so that they may be made available as they are prepared and may be replaced by updated versions without replacing the entire series. It can, therefore, be considered as an open-ended "marine technician's handbook".

For many years there have been such manuals in existence within various groups at the Scripps Institution of Oceanography for internal use. These manuals are being updated, and new ones are being prepared where no satisfactory ones existed; they will be issued as they are ready.

The instructions on physical, biological, and chemical oceanographic data collection and processing have been prepared by members of the Data Collection and Processing Group (DCPG), part of the Marine Life Research Group of Scripps. They cover procedures used by that group. Other chapters on geological and geophysical techniques are based on the "Marine Technician's Handbook" series originally prepared by Mr. Frederick S. Dixon, and issued by the Oceanic Research Division some years ago. It is expected that chapters on techniques used by other groups within Scripps will be added.

Since the sections will be published individually, there will undoubtedly be some repetition. This should not detract from the overall purpose of the manual, since it is expected that a single section will be the only one needed for a particular operation. We do not wish to suggest that the methods described are the only methods; we have merely attempted to describe the methods and procedures which we use and which we have found to be reliable and up-to-date. As new information becomes available, attempts are made to test techniques, incorporate them into routine procedures, and then revise the chapter concerned.

In the final analysis the reliability and quality of the data obtained is in your hands. It is imperative that meticulous attention be given to details to insure reliability and usefulness in the results you obtain.

While we have attempted to be thorough in descriptions of techniques, this cannot be considered to be a complete "cookbook" for the novice. It is in most cases assumed that the reader has some prior knowledge and training in the field concerned. We hope, however, that these instructions can serve as a training aid for the novice marine technician, a "cookbook" for the scientist who is taking his own observations, and a reference manual for the experienced technician.

Preparation of these chapters over the years has been supported by the University of California and by grants and contracts from the many federal agencies to the Scripps Institution of Oceanography and to the Institute of Marine Resources. Support for preparation of this more complete and revised manual has come from the National Sea Grant Program.

Frederick S. Dixon, Meredith Sessions, Richard Shutts, and Paul O'Neill have made significant contributions to the compilation of this section of "The Marine Technician's Handbook". Edgerton, Germeshausen, and Grier, Inc. have aided substantially in granting permission for the use of their instructional material (Instruction Manual, E.G.&G. Sonar Pinger Model 220, Report No. B-2348, 28 May 1962) on the use of the Sonar Pinger.

G. G. Shor, Jr.
Sea Grant Program Manager

Underwater Camera - Wire-Lowered
June 23, 1972

This work is a result of research sponsored by NOAA Office of Sea Grant, Department of Commerce, under Grant #USDC 2-35208 to the Institute of Marine Resources. The U.S. Government is authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright notation that may appear hereon.

UNDERWATER CAMERA - WIRE-LOWERED

HARDWARE

For deep-sea photography Scripps ships use the EG & G International Underwater Camera, Model 200A, 6 volts; the EG & G International Light Source, Model 210A, 6 volts; and the EG & G International Sonar Pinger, Model 220. All carry a precision echo sounder (PDR, GDR, PSR, or other) and a transceiver.

Camera

The camera system consists of a stainless steel frame in which two 35 mm cameras in cylindrical pressure cases are mounted. The camera fields of view are focused at a 45° angle from the horizontal (Figures 1 and 2). Each camera accommodates 150 ft. of Kodak RAR film (see Appendix III) or 100 ft. of color film or Plus-X black-and-white. Since there is no ambient light at operating depths, the camera shutters are locked open.

A "data block" inside the accessible end of the pressure case includes a clock, a depth meter, and a data card. Photographed with every picture, by means of mirrors, this data block appears alongside the frame on the film. The card carries the ship's name, date, position, station number, and other pertinent data.

One of the cameras has a small metal rod dangling about 4 inches in front of the lens. Known as the "dangler," this rod is in vertical position when the camera is tilted and thus indicates the upper and lower portions of the photographs.

Strobe

An electronic strobe unit in its own pressure case is also mounted in the frame. This strobe unit flashes approximately once in every 12 seconds with each flash sending a synchronization pulse to each camera, advancing the film one frame each. This leaves a frame of unexposed film behind the lens with the camera ready for the next flash of the strobe.

A clockwork delay timer in the flash unit's pressure case enables the flash-camera unit to be armed prior to lowering into the water; the flash and advance of film will not begin until the set time has elapsed. This conserves both film and battery power during lowering. When the lowering time is estimated correctly, the timer will start the camera's functioning a minute or so before the camera is at its bottom depth.

Pinger

The Sonar Pinger is also mounted on the steel frame. It is comprised of a pressure case containing electronics and battery power, a pulse transformer, and a 12 kHz transducer. It emits a 1/2 millisecond pulse of 12 kHz sound every second and measures height above bottom by measuring reflection time. The shipboard recorder gives a readout on an echogram 19 inches wide, in multiples of 400 fathoms, allowing detailed echograms of the deep-sea floor with an accuracy of one fathom in depths of 3000 fm.

PREPARATION FOR STATION

Selecting the Station

Camera stations are usually set up in areas just surveyed with echo-sounders and airgun recorder or in those just dredged and, therefore, surveyed. The chief scientist can base his decision to photograph on topographic information gained in the previous operations.

One of the most important of the variables to consider is drift direction. Wind, current and sea conditions determine this. The larger research vessels drift considerably even when dead in the water; the bottom therefore may vary, especially in fracture zones, as much as 200-600 fm in depth during the few hours of a camera station. The slow, steady drift movement is preferable to power motion for camera work since it permits the camera cable to be suspended at an angle closer to vertical and gives better control over the camera's separation from the bottom.

Drift direction should be determined before coming on station and lowering the camera. Inspection of fixes for the previous six or more hours should yield this information. If the ship has been underway, these will show to which side

of the track she has been set and whether she is making more or less than standard speed. This roughly indicates drift direction. If drift-dredging has preceded the camera station, the drift direction is determined by plotting fixes obtained during that operation and also by noting changes in the bottom. However, if surveying has preceded the camera station, the frequent course changes necessary may make it impossible to figure the drift. In this case, drift direction is ascertained during the station by noting movement over the feature just surveyed.

A good photographic bottom can be chosen by observing the echo-sounder record and listening for the strong sound return reflected by rock surfaces that can indicate interesting features such as seamounts and ridges. When the choice has been made, drift direction ideally goes down-slope on a feature in order to minimize the danger of damage to a camera from its being dragged on bottom. To illustrate, in order to photograph at 2000 fm with down-slope drift, the camera is put into the water slightly updrift of the 2000 fm point. It will be at the desired depth by the time it is over the bottom. The ship continues to drift down-slope and wire is payed out to keep the camera constantly just above bottom until the film is exhausted.

When the drift is in the opposite direction, the scientist has less satisfactory options for setting up the station. When photographing a trench with two steep sides of equal photographic value, he may choose to utilize favorable drift direction by photographing the opposite side of the trench. He may, on the other hand, choose to photograph while drifting up-slope or while moving down-slope under power.

Loading the Camera

Prior to arrival on station, technicians check the cameras, strobe, and pinger. A fully-charged battery is installed in the strobe unit and the cameras are checked before being loaded with film.

The top end of each camera case is marked with felt pen as either "B&W" or "Color" to indicate the type of film. The cameras are tested with a piece of old film to be sure they work properly. A camera chassis is removed from its case and set on the bench with a spare battery-camera test box and the top end cap of the case. The test box is plugged into the camera and the battery into the test box. When the button is pushed on the test box, the camera should go through one cycle; the procedure is repeated several

times and then the second camera is tested similarly. When both have checked out satisfactorily, the properly filled data card is inserted on the end cap and the clock is set.

The lens are inspected for cleanliness before the camera is loaded. When the film is supplied on daylight loading spools (417 type), both color and black-and-white film can be loaded under subdued light, but the first foot or two will be exposed. The advantage in using subdued light lies in being able to inspect the film threading operation visually, thus assuring better performance. If the chief scientist wants the film cut into specified lengths, this must be done in complete darkness. Normally, however, an entire 100 ft. reel is loaded, as above, under subdued light and the exposed film is cut off after the operation is completed. The remaining unexposed film is rethreaded on the camera transport for subsequent lowerings.

The slotted film spool gauge on the camera chassis should be used to check the take-up spool width; a bent spool can cause the film to jam and stop. The spools should be snapped securely onto the spool shafts. The film is then pulled carefully through the film gates, emulsion side toward the lens, and around the sprocket as shown by the white line on the camera chassis. Care should be taken to prevent bending of the film gate tabs during loading. It is helpful to tape the end of the film to the hub of the take-up spool. The loaded camera is placed in the black camera bag and is held with one hand through the arm hole of the bag, and the other hand holding the end of the bag closed on the outside. Note that if the camera chassis has grease on it, or the person loading the camera has greasy hands, the black bag can cause grease smears on the camera lens. A clean black camera bag should be used at all times. On deck the end of the black bag is spread over and around the camera case; after the camera is inserted into the case, the hand and black bag can be removed. The end cap is placed on the camera, making certain that the "O" ring is seated correctly and the thumb screw is tightened as much as possible by hand. The above procedure is followed for each camera.

The light source is checked by removing the end cap, battery, and strobe from the case and placing them on the bench with the battery plugged into the timer. The latter is set for five minutes by turning past twenty minutes and then back to five. After the five minutes have elapsed, the light should fire. This procedure checks both the flash unit and timer accuracy, in minutes. After testing, the light source is returned to the case, the battery is disconnected from the timer, and the end cap is replaced. Care is taken again to see that the "O" ring is seated correctly.

In preparing the camera for lowering, the two harnesses having female Joy plugs on the ends should be plugged in; the 6-volt, or red, harness is plugged into the 6-volt male plug on the end caps and the ground, or black, harness is connected to the ground male plug on all three caps. Surplus wire is taped around one case, leaving enough slack to permit the caps to be removed without unplugging the harnesses.

The end caps on all three pieces of equipment have been modified to use the synchronizing plug for a ground since the shutters are always open in deep water work (Figure 3). When the camera is used in shallow water where the shutter must close, the end caps are changed back; the ground wire becomes the synchronizing lead to actuate the shutters, and an extra ground wire must be added. One wire will suffice for this with each end cap grounded under the screw-in cap that is provided for this purpose.

The strobe end cap is removed and the time-delay clock withdrawn. The battery is plugged into the clock-plate and the clock is replaced. With the time-delay clock set at "0" minutes, the end cap is replaced and the light should start operating immediately. After each flash, the operator puts his ear to the camera to check by sound that it is operating. This is done with each camera. When satisfied that both are working properly, the operator removes the end cap from the strobe again and sets the time-delay clock. Lowering and handling time, as well as a margin for unforeseen delays, must be taken into consideration in setting the clock. When the clock is set, the end cap is replaced and should fit easily. If not, it is again removed so that the battery lead routing and clock setting can be checked.

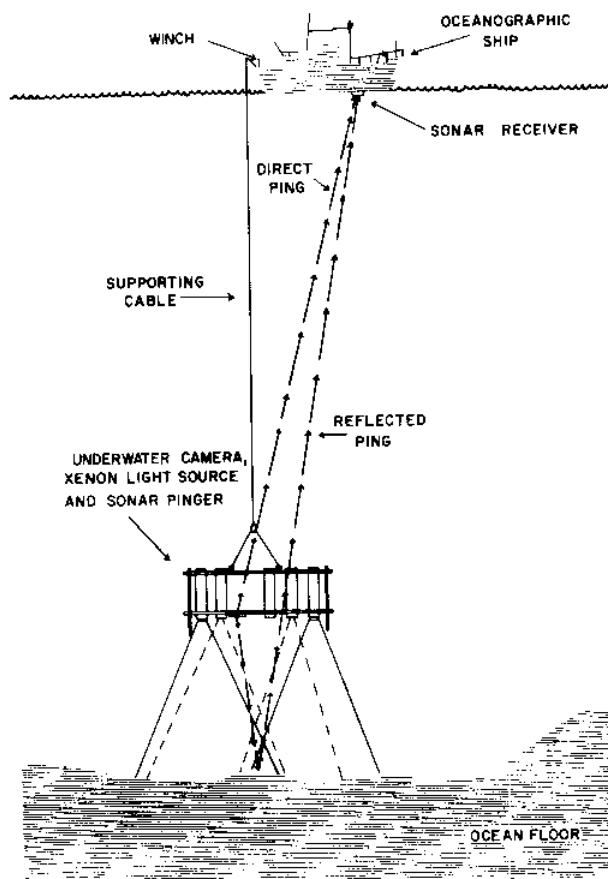
Note that in replacing the end cap, proper seating of the "O" ring is important. With the seating done carefully, the end cap is bolted securely in place. The camera is ready to be lowered. The delay time of the timer, the time set, and the start-down time of the camera is carefully noted on the camera log sheet.

ON STATION

Using the hydro-wire for lowering, the camera is placed in the hydro-bucket with the safety line snapped on. The winch operator prepares to go up slowly on the winch while the camera operator holds back on the camera frame, ready to let it roll over the edge of the bucket.

The lens on the Model 200 cameras are prefocused to 12 feet and will have a depth of field to allow objects between 3.5 and 20 feet to appear in focus. Later models, 200A cameras, have focusing rings and must be checked to see that they are focused correctly. After lowering, the slow turning of the camera due to wire rotation will give pictures at different angles. The optimum camera depth is at the prefocused 12 feet off the bottom and this is maintained as closely as possible by utilizing the direct and reflected sound from the pinger on the camera frame.

The distance between the camera and the bottom is determined by comparing the time difference between the sound pulse received from the camera-mounted pinger in a direct path and the path of the sound pulses reflected from the bottom (see sketch). As the camera approaches the bottom the time difference between reflected and direct paths approach zero and can be viewed on the recorder chart for exact distance determination.



The pinger is plugged in when the camera is clear of the hydro-bucket and the instruments are lowered; when these are just below water surface, the winch is stopped while both winch and lab meter wheels are reset. When resumed, lowering should proceed at less than 90 meters per minute for the first 2500 meters since the camera component has a high drag due to its large surface area and tends to float slightly.

With the ship's echo sounder in the Receive-Only mode and with the gain turned up, the trace patterns on the recorder chart are observed during instrument descent to note the aforementioned separation between the camera and the bottom. As the pinger emits its 1/2 millisecond pulse of 12 kHz sound at a one second interval, the trace of direct sound is shown crossing that

of the reflected sound at 400 fm intervals. Each tenth pulse is blanked to allow matching of the direct and indirect ping.

The crossings must be counted so that the watch stander can anticipate the 0 fm reading in order to slow the camera. To illustrate, if the water depth is 1800 fm, the first crossing will be when the camera is 1600 fm off the bottom; the second when 1200 fm off bottom; the third at 800 fm, and the fourth at 400 fm. The watchstander will stop paying out wire just before the fifth crossing on the echogram.

When the bottom return is such that the pinger is not heard or recorded until nearing the 400 fm or 0 fm depth, an alternative method must be used to determine which 400 fm interval above bottom is being indicated in the trace crossings. In this case, straight forward calculations are employed by ascertaining water depth from the echo sounder and computing the distance from the ship to the 800 fm and 400 fm crossings. The figures are converted to meters by Matthews tables and a chart is made, as below:

WATER DEPTH: 2600 fm

<u>Crossing</u>	<u>Expected wire out (calculated wire out to reach crossing)</u>
2400 fm	378
2000 fm	1123
1600 fm	1867
1200 fm	2618
800 fm	3366
400 fm	4129
000 fm	4895

When the first visible crossing is seen on the recorder, the wire out is recorded and entered in the proper slot, to identify immediately which crossing has just appeared. The actual wire out will always be a little greater than the calculated wire out because of wire angle and "snaking" of the wire. With a relatively light load such as the camera, this snaking can be considerable. Each successive crossing should appear more clearly and the observed wire out can be recorded for each. This data will give some idea of overage, i.e., extra wire needed to reach a certain depth because of spiraling, snaking, etc.

The pinger returns are often masked by noise from the main engine, the uncontaminated sea water pump, the turning of the propellers, the emergency lube oil pump, and the ship's service air compressor. All may be secured during drifting except the compressor which on some ships is responsible for operation of the pneumatic ship controls. This usually runs approximately 10 minutes, then is idle for 20 minutes. When essential pinger returns are unusually weak, the air compressor may be delayed up to 30 minutes from its automatic starting.

When the camera is about 25 fm off the bottom, lowering is stopped to wait for the cameras to turn on. If insufficient time has been set on the timer, so that they are already activated, the operation is stopped for a few minutes to let any slack in the wire be taken up. The camera would otherwise settle to the bottom.

Once positioned, the camera is kept 2 fms above bottom by the watchstander's instructions to the winch operator.

The watchstander is also responsible for knowing when the timer was set, the length of time allotted, and when the camera is to begin photographing. With this data he can determine when the supply of film is exhausted and will signal the winch operator to bring the camera to the surface.

At regular intervals during the station, usually every 5 minutes, the watchstander records the water depth and the meters of wire out. The meters of wire out is also recorded whenever the winch starts in or out, stops, or changes speed.

Appreciable changes from 2 fm in camera-to-bottom distance are also recorded. These data are used later in evaluation of the station.

When the photography is finished, the instruments are brought up at half speed to about half the total meters of wire out, then there is an increase to full speed. The winch is slowed again at 300 meters and the camera operator should be in the hydro-bucket to sight the camera and/or wire tangles caused by putting the camera on the bottom. When the camera frame can be reached, the operator leans over the hydro-bucket and snaps on the safety line. The pinger should be unplugged as soon as possible.

As soon as the camera is hoisted on deck, the rear end cap of the strobe unit should be removed and the battery disconnected. The battery should be placed on the battery charger in preparation for the next lowering and the end cap replaced immediately.

A flashing strobe as the camera is decked is a good sign of undamaged equipment. To protect the film and camera mechanism further, the cameras are not opened immediately after leaving the cold water, except in case of flooding. If the temperature of the interior mechanism and film is cooler than the surrounding air, condensation forms on camera and film. The camera should be brought to ambient temperature before opening. This can be done by rinsing in hot, fresh water. Always rinse the camera unit with fresh water after each lowering.

After the camera cases have come to ambient temperature, the film may be removed, with or without the use of the dark bag. If the bag is not used, however, the last 10 frames or more will be fogged. The cameras should be opened in subdued light at all times.

Black-and-white film is loaded into the developing tank at the same time. Developing instructions follow in the Appendix. Color film is placed in cans and sealed, to be developed ashore. Film data should be appropriately labeled with felt pen on each can. Empty cameras are returned to their cases. The black-and-white film can be developed according to instructions in the Appendix, using Kodak D-19 developer, Kodak rapid fixer, glacial acetic acid and Kodak photoflow, or with Kodak Monobath solution. The latter only requires three steps in processing RAR films: Monobath, Wash, Photoflow and then drying. No Stop Bath or Fix is required. Furthermore, the use of Monobath solution eliminates the necessity for knowing the length of film in the processing tank. The developer will only develop to a certain point and then will stop.

STATION EVALUATION

In order to make a complete evaluation, it is important to know the depth for each print. Although the data block accompanying each frame records time and depth, to date the depth gauge has proved worthless. Furthermore, since the camera is not directly beneath the ship but trailing at an unknown distance, the depth that is recorded by the echo-sounder reading when the picture was taken is not the depth actually photographed.

To determine picture depth, plot the "wire-out figures" against the "time" on a sheet of thin graph paper. Plot the "echo sounder depths" against "time" on another. Make a

note of any changes of ship speed or pertinent data, such as changes in separation on the graphs, at the appropriate times. Superimpose the two graphs over a light table and slide one along the time axis to show correlation between the echo sounder graph and the wire-out graph. A change of bottom slope on the echo sounder graph, for instance, should appear as a change in slope on the wire-out graph several minutes later when the camera would have passed over this point. Many factors can complicate this interpretation, however. Changes in ship speed, constant bottom slope, resting the camera on the bottom, and changes in separation all can contribute to uncertainty of ship-to-camera distance as computed from the echo sounder and the wire-out data.

A working formula has been devised giving t as the time lag between ship and camera and T as the camera depth, so that:

$$\text{Camera Depth (T)} = \text{Echo Sounder Depth (T-t)}$$

but this requires modification to account for depth changes that may be shown by wire-out but may not be shown by the echo sounder. A 10 fm hill in the middle of a 3000 fm sediment plane, for instance, would not be recorded on the echogram but would be "seen" by the camera. If constant separation is maintained over it, this would be reflected in wire-out readings. Small squiggles in the wire-out graph, therefore, may represent true changes in depth even though no correlation appears on the echo sounder graph. For this reason, only major changes in slope are used when determining the ship-camera time lag by the above formula.

Make a tabulation of all separations that have occurred while the cameras were photographing in order to determine the field size and scales of any usable photos.

CAUSES OF STATION FAILURE

An aborted station can be caused by failure of the mechanical and electronic devices. Careful preparation of equipment and awareness of the most common causes of failure help prevent such abortion.

Damaged equipment also causes failures. Should the flash tube break in collision with hard bottom rock, there would be no light for photographing. A collision can also cause flooding of the camera and flash units by bending

the holddown clamps which seal the pressure cases, so that there could be no pictures. If the pinger fails to operate, the camera cannot be positioned at a correct distance from the bottom. Pinger failure is most often caused by either disconnection of the Joy plug that is used to disarm the unit or by disconnection of the plugs inside the pressure case. Careful securing of the connectors guards against such failures. Finally, pinger failure may also be caused if the transducer is damaged by collision with the bottom.

Caution: Pinger must not be plugged in while it is on deck, or directly above a hard (reflecting) surface. The return, in the air, can damage the instrument.

FIGURES

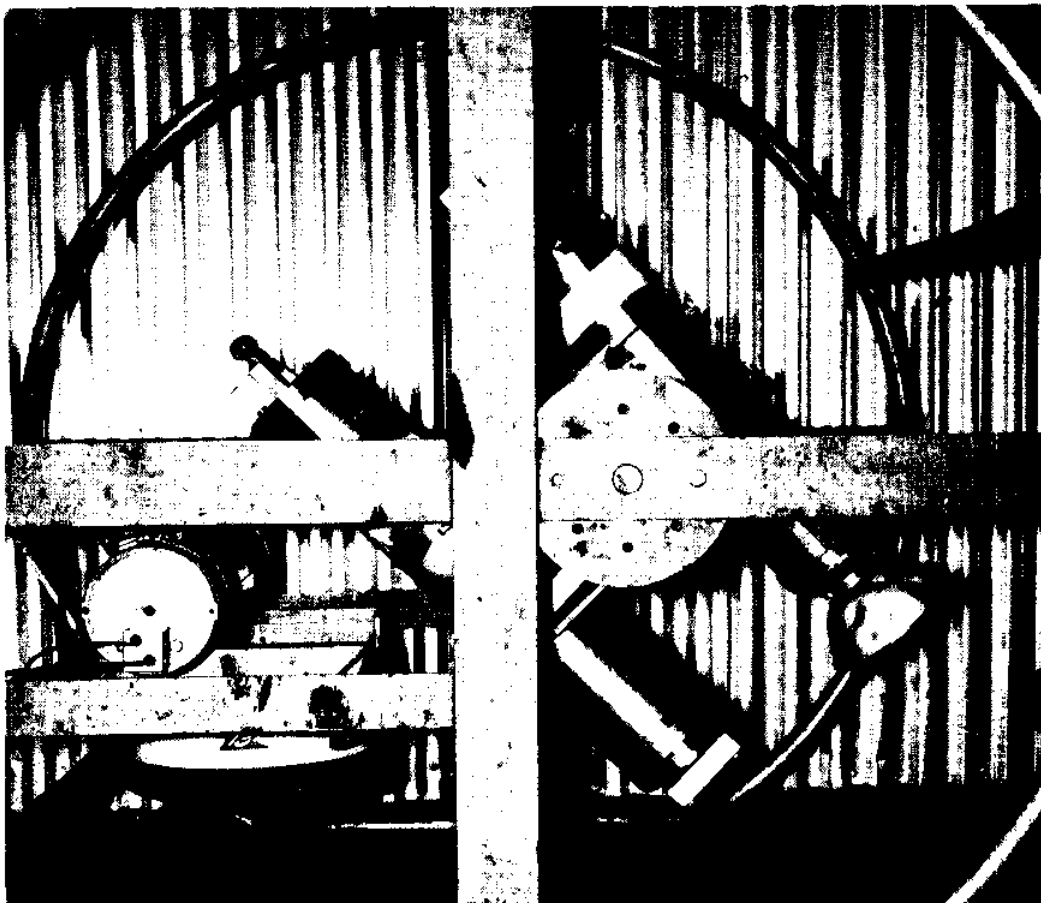


FIG. 1 Camera on underwater frame in stereo configuration (side view).

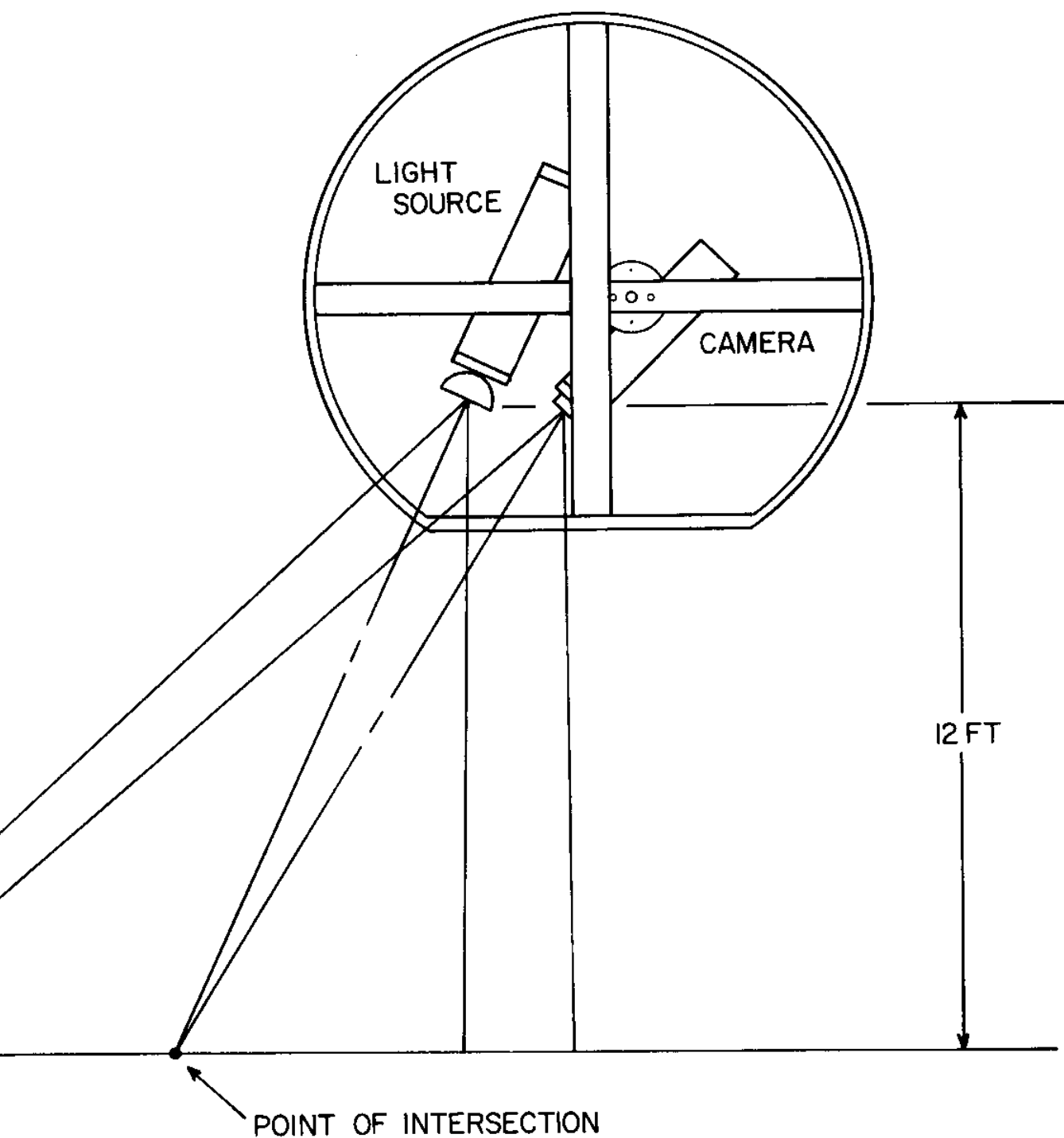


FIG. 2 Camera frame showing axial relationship of units in mounting arrangement.

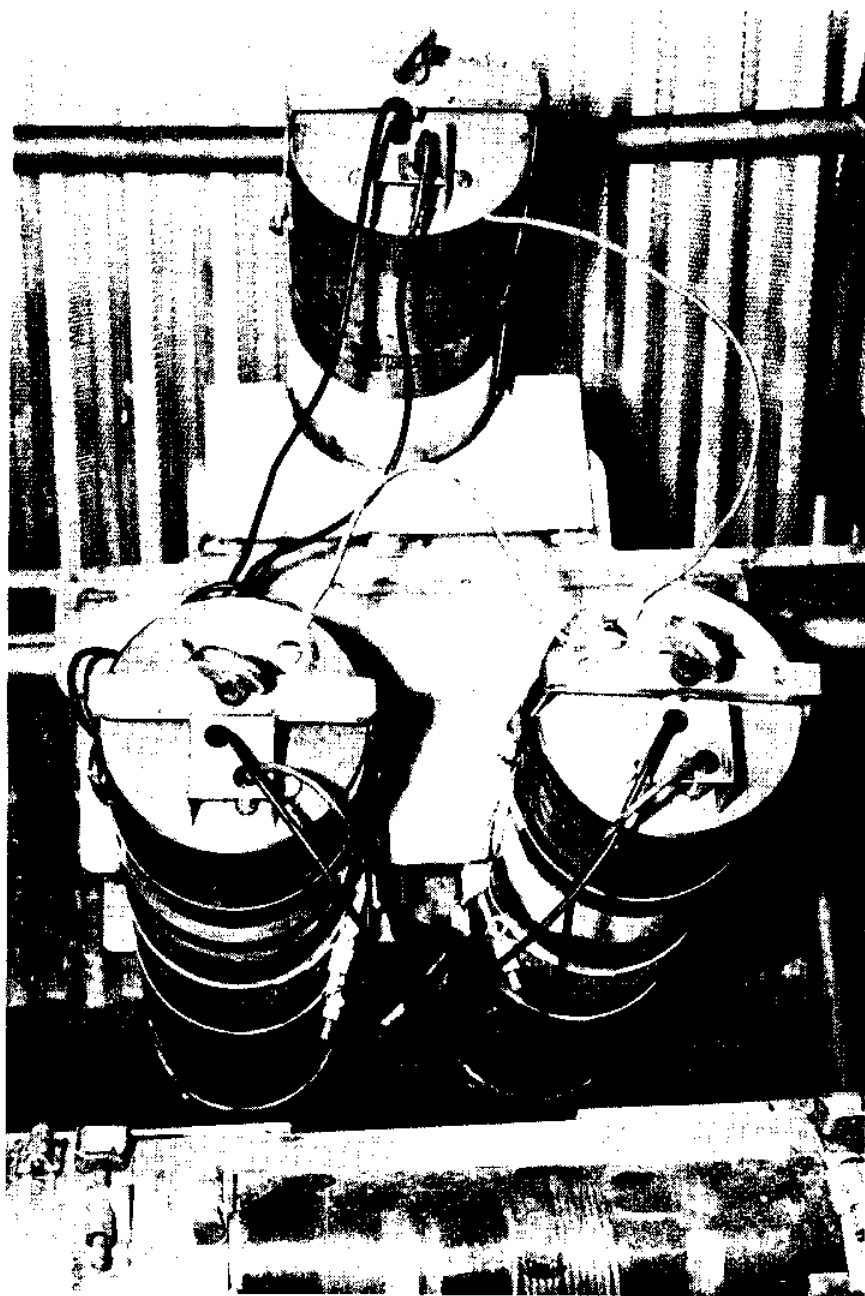


FIG. 3 Camera with ground wire.

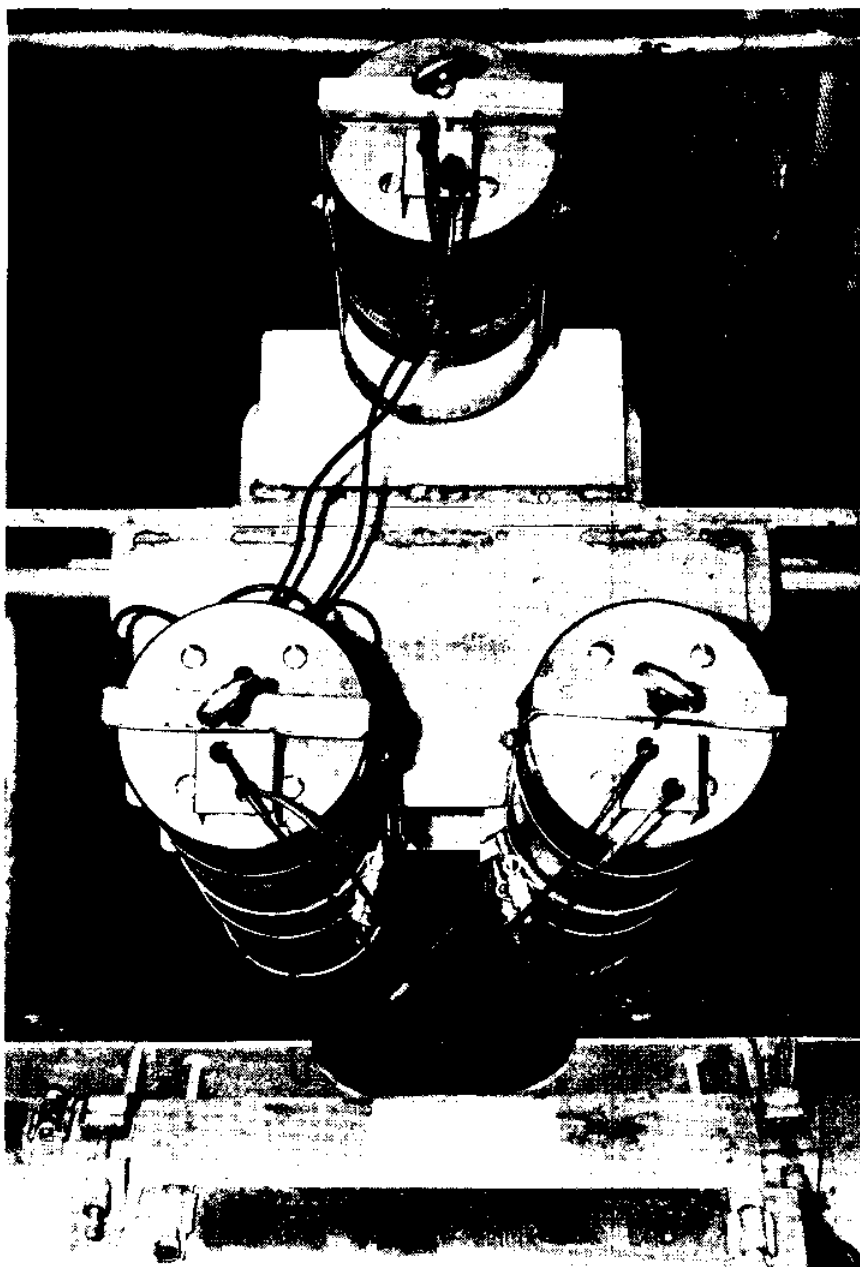


FIG. 4 Camera with Joy plugs.

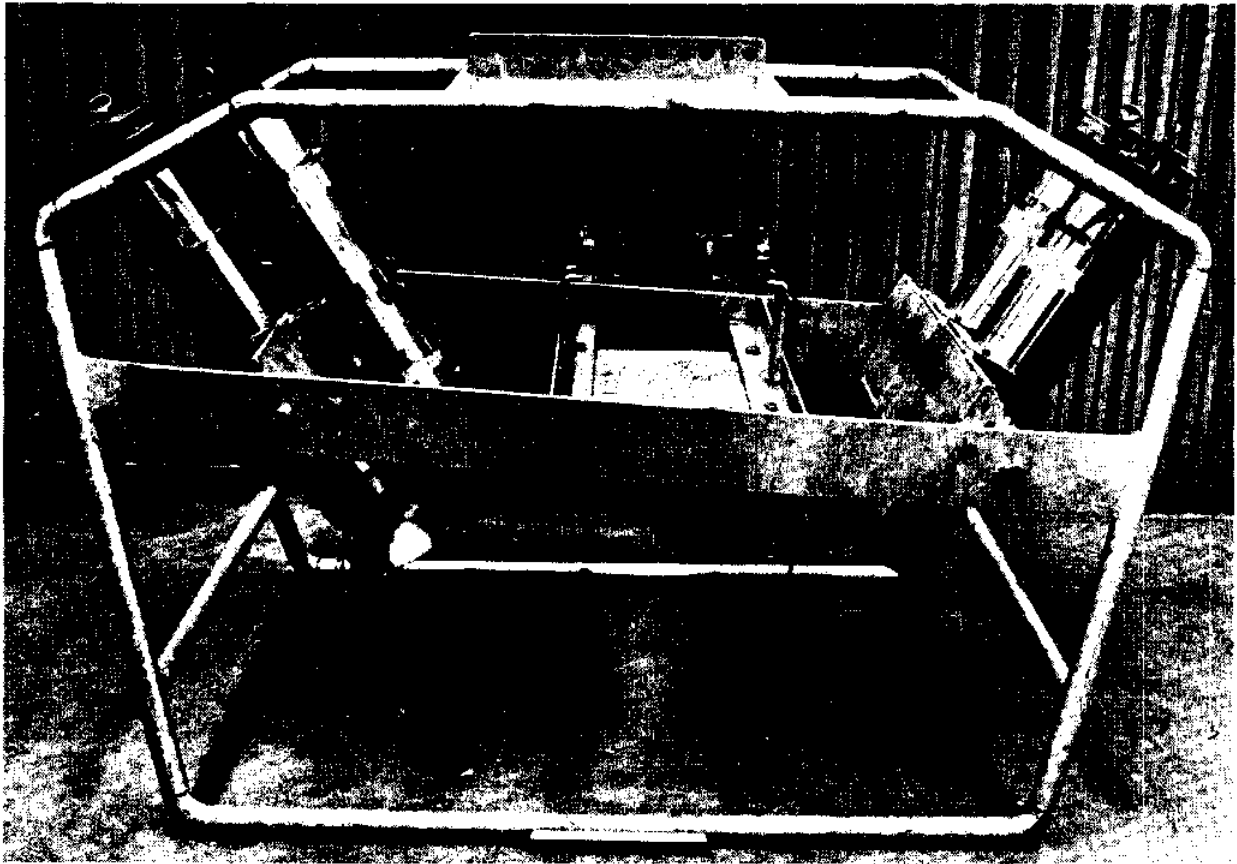


FIG. 5 Modified underwater camera frame.

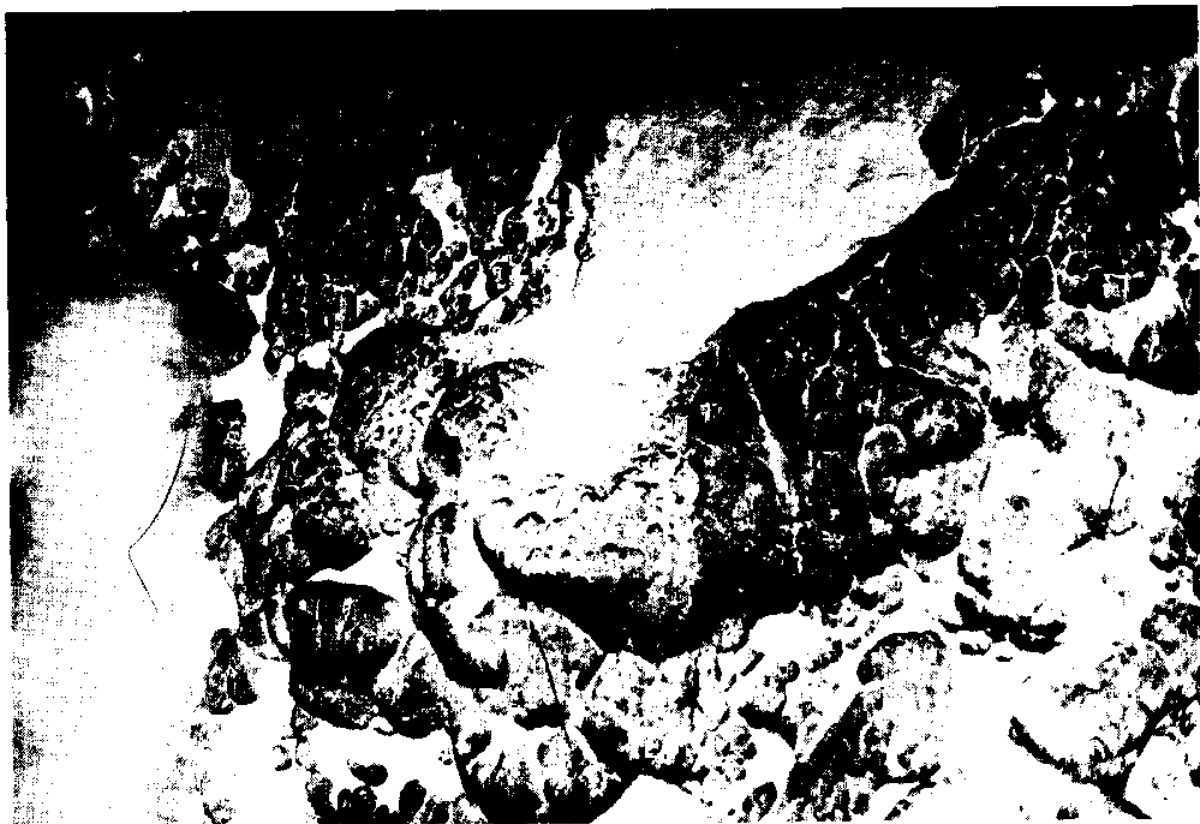


FIG. 6 Manganese-crusting basalt (upper and lower).



FIG. 7 Pillow lava (upper and lower).



FIG. 8 Manganese-crusts basalt with sand ripples.

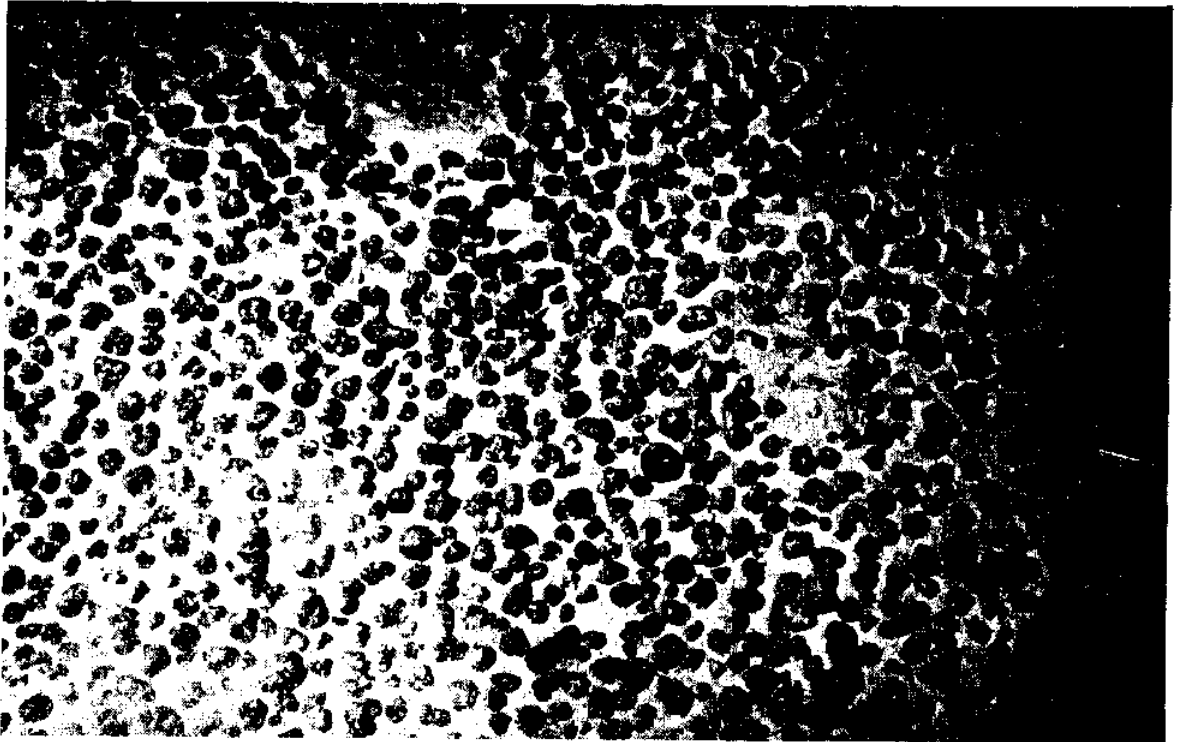


FIG. 9 Manganese nodules.

CAMERA LOG

Ship _____ Expedition _____ Type Camera _____
 Lat. _____ Date _____ Film Left Camera _____ Length _____
 Long. _____ Station # _____ Camera Lowering # _____ Film Right Camera _____ Length _____
 Bathymetry _____ Technician _____ Type Camera Frame _____

Time Set _____ Start Down _____
 Delay + _____ On Bottom _____
 Camera Goes On _____ On Deck _____
 Camera Operating _____
 Camera Goes Off _____

REMARKS:

APPENDICES

APPENDIX A

DEVELOPING THE FILM

PROCESSORS

Depending on the equipment aboard, Scripps ships use one of the following methods for developing film: the Morse G-3 16-35 mm Developing Tank; the Micro-Record Tank, with motor; and the Bimat process.

I. Operating instructions for the Morse G-3 16-35 mm Developing Tank.

The Morse G-3 developer is a manually operated rewind processing tank for double-8, 16 and 35 mm motion picture film. The G-3 requires a minimum of 32 ounces of solution to process double-8 or 16 mm film. Sixty-four ounces of solution are required for 35 mm film. The film may be processed completely, through reversal to a positive image ready for projection, or to a negative image from which positive copies can be made.

An inexpensive mechanical device, the G-3 must be hand turned. At the rate of two turns per second, 100 feet of film will pass from one reel to another in approximately one minute. In turning the cranks, however, caution to prevent excessive clinching of the film at the end of each pass is of greater importance than rate of speed.

A. Loading Instructions:

1. The window (for re-exposure) should face the operator. Remove the tank cover and reels.
2. Adjust the top plate on both reels to the proper width for the film being processed, 16 mm or 35 mm (double-8 is the same as 16 mm).
3. Load film in total darkness. Place the film spool on the right-hand spindle to unwind counter-clockwise and place the empty reel on the left spindle.

4. Insert the end of the film in the left-hand reel and clamp. To insure straight winding, give the reel two clockwise turns, loosen the clamp, and then reclamp. Be sure that the end is securely clamped before continuing the operation. The two spindles revolve in opposite directions only during the unwinding of the film spool. By loading in this manner, the film can be wound EMULSION SIDE OUT.
5. Place the cover in position and wind the left hand crank clockwise until all of the film is off the spool.
6. Remove the cover and the empty film spool. Replace the right-hand reel, insert the loose film end into the reel, and clamp.
7. Pass the film over the idler roll, giving the right hand reel two full turns. To assure in-line position of the film, loosen the clamp and retighten.
8. Replace the tank cover, taking care that the cover snaps are in place, that the re-exposure window is to the front, and that the window cover is closed.
9. After the tank cover is in place and the re-exposure window cover is closed and facing the operator, the remaining operations may be carried out with the room light on.

B. Processing Instructions:

1. Pour solutions into the tank through the opening on the top of the tank cover. Empty them by pulling out the rubber stopper located in the bottom of the tank, beneath the window cover. Both the inlet and outlet are light proof. Wind the crank in the direction indicated by the arrow on the tank cover. Each crank has its direction indicated by an arrow beneath it.
2. Wind the film back and forth at a rate that will pass 100 feet of film from one reel to the other in approximately 60 seconds. Adjust the rate of winding to provide a whole number of "round trips", i.e., complete transfers from one reel to the other

and back again, in each bath. All portions of the film will thereby have the same time of contact with the bath. When using the Monobath solution, however, timing is not critical. The times required in the various steps with D-19 will depend upon the length of the film roll since the film is tightly wound for greater periods of time than it is in free contact with the solution. The times given here are in terms of 100 ft. rolls. If the film should be cut into 50 ft. rolls, decrease the time 25%; with 25 rolls, decrease the time 50%. Fresh solution should be used for each roll processed. Use running water for the final wash, or drain the water and replace it after each round trip.

II. The Micro Record Processor.

In this process a motor and transmission causes the film to travel back and forth from reel to reel. The reversal of rotation is determined by using a short length of leader attached to each spool. When the reel being unwound is exhausted, the rotations of the spools are reversed. Up to 200 ft. of film can be processed at one time.

To Process:

- A. Remove spool and attach a 5 to 10 ft. leader to each core.
- B. Replace one spool and place the other on a film winder.
- C. Turn out the lights. Open the film and staple one end to the leader. Handcrank the film onto the processor spool, with emulsion side in.
- D. Remove the film on the spool from the film winder and place it on the axle of the processor. Staple the loose end to the leader on the other spool. Position the solenoid switch levers over the top of the film.
- E. Place the light trap on the processor and turn on the lights.

- F. The processor has three process trays and a wash tank. At the beginning of each step in processing, the tray is filled with solution and the processor is lowered into the tray. The motor must be turned on and left on until processing and washing are completed. The processor is transferred from tray to tray until processing is complete.

III. Kodak Bimat Transfer Processing System.

This system of processing requires a Mark Systems Model 200B or equivalent processor and 35 mm pre-soaked Bimat Transfer film. The system works as follows:

The camera film RAR 2496 is laminated to a pre-soaked Bimat Transfer film of the same size. This transfer film contains the chemicals required to process the film. The process is self-limiting. That is, the development process goes to completion and then stops. The films, therefore, can remain in contact with each other for a considerable length of time provided they are not allowed to dry.

Minimum processing time: 10 minutes at 75°F

When the two films are separated, they provide a fully processed negative and a Bimat positive. Films should be washed for 10-15 minutes and dried. If the positive is to be kept, it must be laminated. For types of Bimat with appropriate instructions, etc., see the instruction manual pertaining to the processor.

APPENDIX B

PROCESSING CHEMICALS

I. Recommended Procedure with D-19 Developer (using Morse G-3 Processor or Micro Record Processor)

The recommended developer temperature is 20°C (lab temperature). Other baths should be between 18°C and 23.5°C.

When using D-19 as a developer, it is necessary to know the exact length of the film so that timing for each solution can be carried out properly. The following procedure is for developing 30 ft. of film in the tank. Times are doubled for a 100 ft. roll:

1.	Develop	D-19	4 minutes
2.	Stop Bath	1 A	2 minutes
3.	Fix	Rapid fixer	10 minutes
4.	Wash	Running salt water	20 minutes
5.	Wash	Fresh water	2 minutes
6.	Wash	Fresh water, plus 1 cap Photo Flow	2 minutes

When developing is completed, cut the film into desired lengths (5 ft. is suggested) and hang to dry.

Stop-Bath SB-1A

Water	1 gallon
*Acetic acid, 28%	16 ounces

*To make approximately 28% acetic acid from glacial acetic acid, dilute three parts of glacial acetic acid with eight parts of water.

Note: One reel to another requires 30 seconds for a 30 ft. roll.

II. Kodak 448 Monobath Processing (using Morse G-3 or Micro Record Tank)

This is a single-solution chemical designed for rapid, simplified processing of Kodak films. Monobath simultaneously develops and fixes film to give records of reasonable permanence in as short a time as 15 seconds, depending upon film and temperature.

A. Temperature Range:

It is generally recommended that processing temperatures be within the range of 85°F (28°C) to 110°F (43°C). At temperatures above 110°F, the rapid increase in fog will not be offset by a corresponding gain in speed and contrast. Below 85°F, speed and contrast fall below values considered useful.

B. Processing Time:

2496 PAR (ESTAR Gray Bar) is processed to a negative according to the following times and temperatures:

1. At 68°F (20°C) process for 1 to 2 minutes.
2. At 95°F (35°C) process for 30 to 45 seconds.
3. At 110°F (43°C) process for 20 to 30 seconds.
4. At 120°F (49°C) process at 15 to 30 seconds.

Film may be left in solution up to 10 minutes without adverse effects. If film is not processed for the minimum time recommended, satisfactory clearing may not result.

C. Wash Time:

The minimum wash time is 30 seconds in running water at 85°F - 120°F.

When using the Morse Tank or Micro-Record Tank, processing times can be carried out up to 10 minutes without danger of harming the film. Washing can be carried out until the water appears clean (approximately 5 minutes).

D. Storage Life of Kodak 448 Monobath:

1. In original sealed containers
 - a) 18 months in temperature to 80°F.
 - b) 4 months in temperature to 130°F.
2. Unused mixed solution: 2 weeks up to 130°F.
3. Partially used solution: 4 hours from time of first use.

For specifications on other films, see Kodak Pamphlet #P-78.

III. Bimat Transfer (see APPENDIX A, Paragraph III).

APPENDIX C

FILMS USED AT PRESENT IN UNDERWATER PHOTOGRAPHY

- I. Kodak Plus X - spec. 417 (spool loaded for subdued light loading). ASA rating 125. This can be processed with D-19 in Morse Tank or Micro-Record Tank
- II. Kodak RAR 2496 - spec. 417 (spool loaded for subdued light loading). Photo recording sensitivity 125. This can be processed with D-19 in Morse Tank or Micro Record Tank, with Monobath solution in the above tanks, or with a Bimat process.
- III. Kodak Ektachrome EF Film 5241 - spec. 417 (spool loaded for subdued light loading). ASA rating 160. This is color film and should be sent to a lab that has continuous process machines.

